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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :
B01F 7/26

A1

(11) International Publication Number: WO 94/26402

(43) International Publication Date: 24 November 1994 (24.11.94)

(21) International Application Number: PCT/GB94/00942

(22) International Filing Date: 3 May 1994 (03.05.94)

(30) Priority Data:
9309497.7 8 May 1993 (08.05.93) GB

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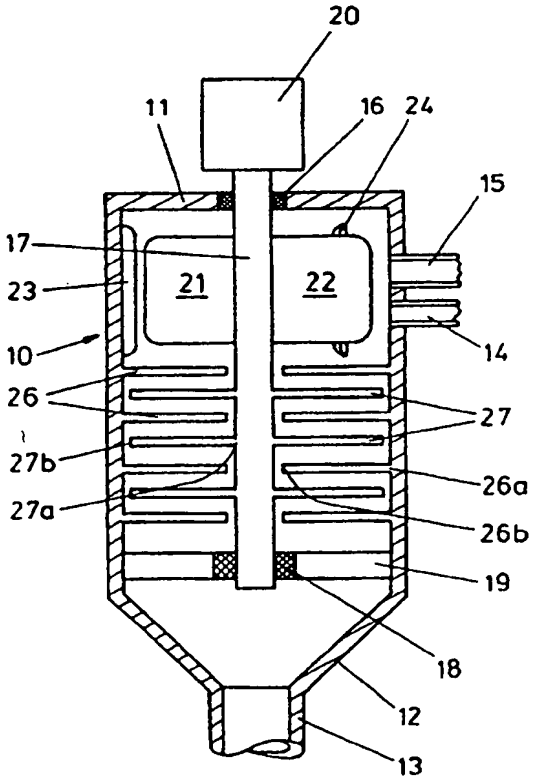
(81) Designated States: AU, BB, BG, BR, BY, CA, CN, CZ, FI, HU, JP, KP, KR, KZ, LK, LV, MG, MN, MW, NO, NZ, PL, RO, RU, SD, SK, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: MIXING ARRANGEMENTS

(57) Abstract

The invention relates to a mixing arrangement comprising a casing (10), inlet means (14, 15) for supplying materials to be mixed to said casing, outlet means (13) for discharging mixed materials from said casing and a rotatable assembly for mixing the materials in said casing. In one embodiment the rotatable assembly is rotatably supported in the casing and comprises a shaft (17), with a plurality of rotatable elements (27), in axially spaced relationship, mounted thereon for rotation therewith, the casing presents a plurality of fixed elements (26) and each major surface of each intermediate rotatable element lies facing, but spaced from, the major face of a fixed element individual thereto. The fixed elements present their major surfaces generally parallel to the major surfaces of the rotatable elements and at right angles to the axis of the shaft. With this arrangement the materials being mixed are directed to flow radially and successively between the major surface of each fixed element and the major surface of the cooperating rotatable element as said materials flow towards the outlet from the casing.



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MIXING ARRANGEMENTS

This invention relates to mixing arrangements and, more particularly but not exclusively, to arrangements for mixing two liquid materials to form an emulsion.

Emulsions comprising at least two materials, one essentially liquid defining the continuous phase for the emulsion and the other or others comprising the discontinuous phase, are well known in the art. In the conventional method for making a liquid emulsion the two basic liquids are mixed in a mixing bowl by a rotating mixing element or elements, the mixing element or elements induce laminar flows in the two liquids adjacent said mixing element(s) to produce an intimate mixing thereof and the mixing is continued until all the discontinuous phase material has been incorporated into the continuous phase material.

Disadvantages with the above identified emulsion mixing arrangement are that the arrangement can only work on a batch system, the time taken to work the two materials into an emulsion is substantial and irregular from batch to batch, so that the mixing arrangement is not suitable for supplying present day continuous requirements, and the volumes constituting the discontinuous phase are irregular, over a very wide range of volumes, which can be reduced only by extending the mixing process, making the batch time longer and even more irregular.

The present invention seeks to provide a mixing arrangement, capable of providing an emulsion of substantially regular discontinuous phase volumes, and of operating as a continuous process.

According to the present invention there is provided a mixing arrangement comprising a casing, a rotatable assembly supported in said casing and means for rotating the rotatable assembly relative to said casing, characterised by inlet means for supplying emulsion materials to said casing, outlet means for discharging emulsion from said casing, and wherein the rotatable assembly comprises a shaft with at least one element mounted thereon for rotation therewith, said rotatable element presents major surfaces inclined to the direction of the axis of the shaft, said casing presents at least one fixed element supported by the casing, said fixed element presents major surfaces generally parallel to the major surfaces of the rotatable element and wherein the emulsion material is directed to flow radially between one major surface of said fixed element and one major face of said rotatable element.

In a preferred embodiment the said rotatable shaft supports a plurality of rotatable elements, the casing presents a plurality of fixed elements and each intermediate rotatable element lies between adjacent fixed elements individual thereto.

Preferably the said major surfaces of the said rotatable elements and the said fixed elements lie in parallel planes at right angles to the rotational axis of the rotatable assembly.

Preferably the said rotatable elements are equally spaced apart in the direction of the rotational axis of said rotatable assembly and each fixed element lies equally spaced from its adjacent rotatable elements.

In a preferred embodiment the, or each, said fixed element comprises an annular element, the outer diameter of said element is attached to the casing and the inner diameter of said element lies adjacent to, but spaced from, the said shaft.

Preferably with such an embodiment each rotatable element is of annular form and has it's inner diameter regions secured with the said shaft and it's outer diameter adjacent to, but spaced from, the casing.

Preferably said inlet means discharge the emulsion materials into a region of the casing upstream of the fixed and rotatable elements, whereupon the emulsion materials must flow radially through all the spacings between the fixed and rotatable elements to the discharge outlet.

In one embodiment the fixed and rotatable elements present plane major surfaces but in another embodiment the fixed and/or rotatable elements include passages, in the form of circular apertures or non-circular apertures, through their thickness and through which emulsion can flow.

In another embodiment the said elements with passages therethrough may be formed wholly or partially by a mesh material.

In one preferred embodiment the rotatable assembly includes mixing means, in that region of the casing into which the emulsion materials are first introduced into the casing.

In another embodiment the emulsion materials are subjected to a pre-mixing means before being discharged into the casing and,in a preferred embodiment, the emulsion materials are passed through a static mixer before being released into the casing.

In one preferred embodiment emulsion materials are continuously supplied to the casing and mixed emulsion is continuously discharged from the outlet means for the casing.

The present invention also envisages a method for forming emulsions comprising the steps of supplying emulsion forming materials to a casing containing a rotatable assembly, rotating the assembly and discharging the formed emulsion from the casing, characterised by the steps of arranging the rotatable assembly to comprise a rotatable shaft with at least one element mounted thereon for rotation therewith, defining the, or each, rotatable element to present major surfaces

inclined to direction of the axis of the shaft and an outer diameter close to, but spaced from, the casing, arranging said casing to present at least one fixed element supported by the casing and defining the, or each, said fixed element to present major faces generally parallel to the major surfaces of the rotatable element(s) and an inner diameter concentric with, but spaced from, the said shaft, the said rotatable and fixed elements being arranged to alternate in the axial direction of the said shaft and causing said emulsion forming materials to flow radially between all the opposing major surfaces of said element as the emulsion forming materials flow through the casing to the discharge from the casing.

Preferably the method is characterised by the steps of supporting a plurality of rotatable elements on said shaft, spacing said rotatable elements apart in the axial direction of said shaft and providing a fixed element between each adjacent pair of rotatable elements whereby to cause the emulsion forming materials to pass radially between each rotatable element and the fixed elements adjacent thereto.

In one preferred embodiment the method is characterised by the steps of arranging the major faces of the rotatable elements and the fixed elements to lie in parallel planes at right angles to the rotational axis of the rotatable assembly.

Preferably the method includes the steps of arranging apertures through the fixed elements to enable emulsion forming materials to pass axially through said apertures.

In one embodiment the method is characterised by the steps of arranging apertures through the rotatable elements to enable emulsion forming material to pas axially through said apertures.

Preferably the method includes the steps of passing the emulsion forming material through a mixing chamber within said casing prior to allowing the emulsion forming materials to pass to the rotatable and fixed elements.

In one embodiment the method is characterised by the steps of passing the emulsion forming material through a pre-mixing arrangement before supplying said emulsion forming materials to the said casing.

Preferably the method includes the steps of continually passing emulsion forming material into the said casing and continually discharging formed emulsion from said casing.

The invention will now be described further by way of example with reference to the accompanying drawings in which;

Fig 1. shows an axial cross-section through a mixing arrangement in accordance with the invention.

Fig 2. shows one arrangement for a rotatable element viewed in the direction of the rotational axis.

Fig 3. shows second rotatable element arrangement capable of being used in the arrangement illustrated in Fig 1.

Fig 4. shows a third embodiment for a rotatable element; and

Fig 5. shows an alternative arrangement for introducing the emulsion materials to the arrangement shown in Fig 1.

In the example illustrated in Fig 1. a generally cylindrical casing 10 is closed at it's top end (as viewed in Fig 1.) by a substantially flat top 11 and is closed at it's lower regions (as view in Fig 1.) by a conical bottom 12 which tapers downwardly to an outlet 13. Liquid material to form the continuous phase of the emulsion is supplied to the casing 10 via a conduit 14 and material to form the discontinuous phase of the emulsion is supplied to the casing 10 via a conduit 15.

A bearing 16, supported in the flat roof 11, supports the upper regions of a shaft 17 and a bearing 18, supported by a spider 19 in the lower regions of the casing 10, supports the lower end of the shaft 17, whereby said shaft 17 can be rotated by a prime mover 20 so as to rotate about a rotational axis concentric with the axis of the cylindrical

casing 10.

The shaft 17 has two diametrically opposite paddle blades 21 and 22 attached to it's upper regions within the casing 10 and the paddles 21, 22 rotate within the free surfaces of three radial ribs 23, 24 and 25, only ribs 23 and 24 of which are illustrated, presented by the casing 10. The conduits 14 and 15 discharge their respective materials into that region of the casing 10 swept by the paddles 21, 22.

Below the ribs 23, 24 and 25 the casing 10 presents a plurality of fixed elements 26, equally spaced apart in the axial direction of the shaft 17, and each said fixed element 26 comprises an annular element the outer periphery 26a of which is secured to the casing 10 and the smallest diameter 26b of which lies adjacent to, but out of contact with, the shaft 17. The shaft 17 supports annular rotatable elements 27, the innermost diameter regions 27a of which are secured to the shaft 17 and the outer diameter 27b of which lies adjacent to, but out of contact with, the cylindrical wall of the casing 10. In the illustrated embodiment each rotatable element 27 is located mid way between the two adjacent fixed elements 26 individual to that rotatable element 27.

In the operation of the device illustrated in Fig 1. the rotatable assembly comprising shaft 17, paddles 21 and 22, and rotatable elements 27, is rotated by the prime mover 20 and the two materials to form the emulsion are supplied to the upper regions of the casing 10 by the conduits 14 and 15, the said two materials being supplied to the casing 10 in the desired proportions to achieve the desired emulsion.

With the upper regions of the casing 10 charged with the emulsion materials the paddles 21 and 22 generate flows within the two materials to generally mix the two materials together and this initial mixing is aided by the shear forces exerted by the paddles 21 and 22 as they pass the free faces of the ribs 23, 24 and 25. The premixed materials flow axially through the assembly of fixed and rotating elements 26 and 27 and through the spider 19 to the conical bottom 12, from which the emulsion flows out of the mixer via the outlet duct 13.

In one method for operating the mixing apparatus illustrated in Fig 1. the fixed and rotatable elements 26 and 27 may present uninterrupted major surfaces, whereupon the mixture of emulsion materials flowing from the chamber above the uppermost fixed element 26 flows downwardly between the shaft 17 and the inner diameter 26b of the said first fixed element 26 and therefrom the emulsion flows radially outwardly between the first fixed element 26 and the first rotatable element 27 towards the internal wall of the casing 10. Therefrom, the emulsion flows axially, as viewed in Fig 1, downwardly between the wall of the casing 10 and the outer diameter 27b of the first rotatable elements 27 into the space between the first rotatable element 27 and the second fixed element 26. In the space between the first rotatable element 27 and the second fixed element 26 the emulsion flows radially inwardly to flow over the inner diameter 26b of the second rotatable element 27 into the radial spaces between the second rotatable element 27 and the third fixed element 26.

Thus, between successive axial displacements, the emulsion is caused to flow radially between a rotating surface and a fixed surface and this radial displacement between relatively moving surfaces generates laminar flows in the emulsion which effectively break down the larger volumes of the discontinuous phase to generate a so-called "micro emulsion", with very small but regular volumes of discontinuous phase material dispersed through the continuous phase material.

In another embodiment for operating the apparatus illustrated in Fig 1. the fixed, and/or the rotatable elements may include apertures therethrough, Fig 2. shows an axial view of one rotatable element 27 with circular apertures 27a therethrough, Fig 3. shows an axial view of an alternative element 27 with an annular region defined by a mesh 27b and Fig 4. shows a further arrangement for a rotatable element 27 wherein the said element 27 has radially extended slots 27c therethrough. In all the said apertured arrangements part of the emulsion will pass through the thickness of the apertured element 27 whilst other parts of the emulsion will flow substantially across the radial width of the element 27 to achieve an intimate mixing of the emulsion materials.

The fixed element 26 may also be apertured, in similar manner to the elements 27 and preferably the apertures through the elements 26 are radially spaced from the apertures through the elements 27.

In a further embodiment the two ducts 14 and 15 for supplying emulsion materials to the casing 10 may be replaced by a single inlet 31 which houses a conventional static mixer 32. The two emulsion materials are supplied to the upstream end of the static mixer 32, conveniently via ducts 33 and 34, and by this means a premixing of the emulsion materials is obtained before said materials are released into the casing 10.

It will be appreciated that the number of fixed and rotatable elements 26, 27 can be varied, the radial dimensions of the fixed and rotatable elements 26, 27 can be varied, the distance between each fixed and rotatable element 26 and 27 can be varied and apertures 27a, 27b or 27c through the fixed and/or rotatable elements can be varied but the optimum dimensions and arrangements can be readily determined from the desired volume range for the discontinuous phase materials and the desired throughput for the apparatus.

Whilst the present invention has been described by way of specific embodiments the invention is not limited thereto and many modifications and variations will be apparent to persons skilled in the art.

CLAIMS

1. A mixing arrangement comprising a casing, a rotatable assembly supported in said casing and means for rotating the rotatable assembly relative to said casing, characterised by inlet means for supplying emulsion materials to said casing, outlet means for discharging emulsion from said casing, and wherein the rotatable assembly comprises a shaft with at least one element mounted thereon for rotation therewith, said rotatable element presents major surfaces inclined to the direction of the axis of the shaft, said casing presents at least one fixed element supported by the casing, said fixed element presents major surfaces generally parallel to the major surfaces of the rotatable element and wherein the emulsion material is directed to flow radially between one major surface of said fixed element and one major face of said rotatable element.

2. A mixing arrangement according to claim 1 characterised in that the rotatable shaft supports a plurality of rotatable elements, the casing presents a plurality of fixed elements and each intermediate rotatable element lies between adjacent fixed elements individual thereto.

3. A mixing arrangement according to claim 2 characterised in that the said major surfaces of the said rotatable elements and the said fixed elements lie in parallel planes at right angles to the rotational axis of the rotatable assembly.

4. A mixing arrangement according to claims 2 or 3 characterised in that the said rotatable elements are equally spaced apart in the direction of the rotational axis of said rotatable assembly and each fixed element lies equally spaced from its adjacent rotatable elements.

5. A mixing arrangement according to any one of claims 1 to 4 inclusive characterised in that the, or each, fixed element comprises an annular element, the outer diameter of said element is attached to the casing and the inner diameter of said element lies adjacent to, but spaced from, the said shaft.

6. A mixing arrangement according to any one of claims 1 to 5 inclusive characterised in that the, or each, rotatable element is of annular form and has it's inner diameter regions secured with the said shaft and it's outer diameter adjacent to, but spaced from, the casing.

7. A mixing arrangement according to any one of claims 1 to 6 inclusive characterised in that said inlet means discharge the emulsion materials into a region of the casing upstream of the fixed and rotatable elements, whereupon the emulsion materials must flow radially through all the spacings between the fixed and rotatable elements to the discharge outlet.

8. A mixing arrangement according to any one of claims 1 to 7 inclusive characterised in that the fixed and rotatable elements present plane major surfaces.

9. A mixing arrangement according to any one of claims 1 to 8 inclusive characterised in that the fixed and/or the rotatable elements include passages through their thickness through which emulsion can flow and said passages are in the form of circular apertures.

10. A mixing arrangement according to any one of claims 1 to 8 inclusive characterised in that the fixed and/or the rotatable elements include passages through their thickness through which emulsion can flow and said passages are in the form of non-circular apertures.

11. A mixing arrangement according to claims 9 or 10, characterised in that the said elements are formed, at least partially, by a mesh material.

12. A mixing arrangement according to any one of the preceding claims characterised in that the rotatable assembly includes mixing means, in that region of the casing into which the emulsion materials are first introduced into the casing.

13. A mixing arrangement according to any one of the preceding claims characterised in that the emulsion materials are passed through a pre-mixing means before being discharged into the casing.

14. A mixing arrangement according to any one of the preceding claims characterised in that emulsion materials are continuously supplied to the casing and mixed emulsion is continuously discharged from the outlet means for the casing.

15. A method for forming emulsions comprising the steps of supplying emulsion forming materials to a casing containing a rotatable assembly, rotating the assembly and discharging the formed emulsion from the casing, characterised by the steps of arranging the rotatable assembly to comprise a rotatable shaft with at least one element mounted thereon for rotation therewith, defining the, or each, rotatable element to present major surfaces inclined to direction of the axis of the shaft and an outer diameter close to, but spaced from, the casing, arranging said casing to present at least one fixed element supported by the casing and defining the, or each, said fixed element to present major faces generally parallel to the major surfaces of the rotatable element(s) and an inner diameter concentric with, but spaced from, the said shaft, the said rotatable and fixed elements being arranged to alternate in the axial direction of the said shaft and causing said emulsion forming materials to flow radially between all the opposing major surfaces of said element as the emulsion forming materials flow through the casing to the discharge from the casing.

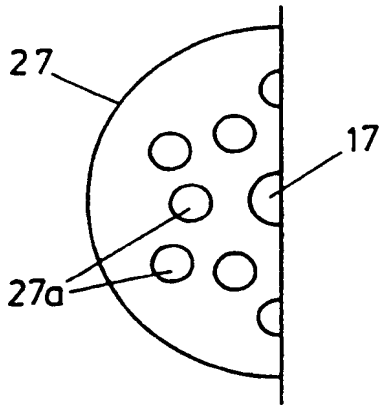

FIG. 2

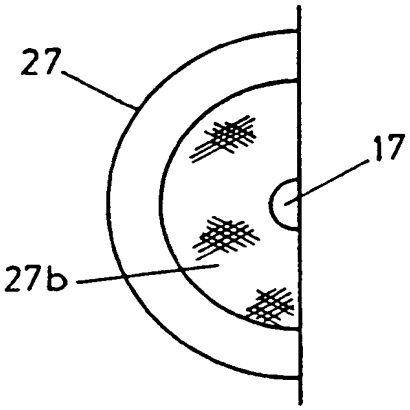

FIG. 3

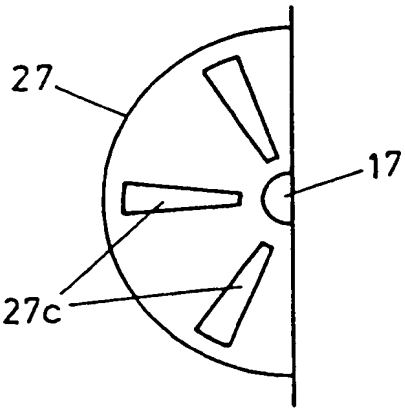

FIG. 4

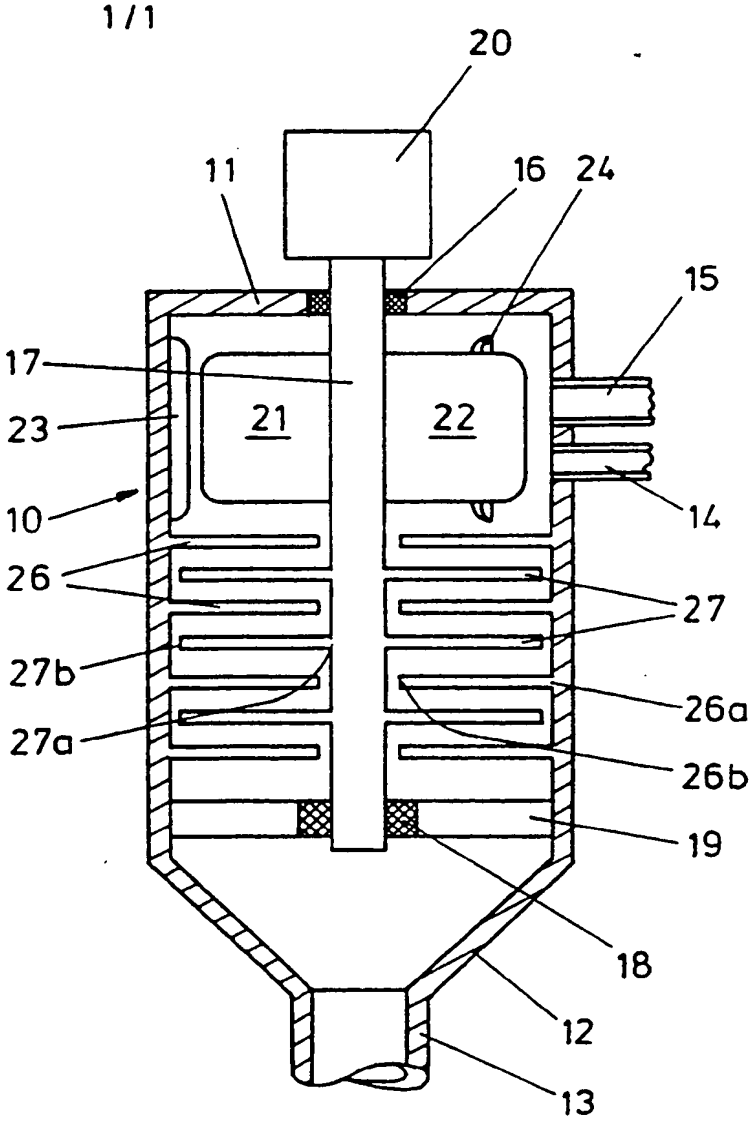

FIG. 1

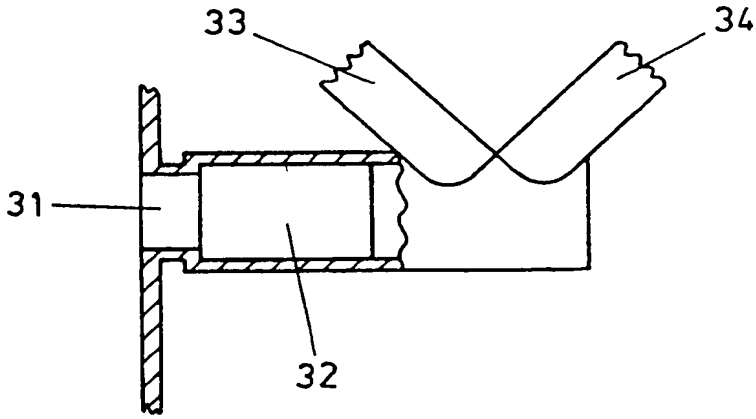

FIG. 5

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 B01F7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 B01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US,A,2 092 992 (THALMAN) 14 September 1937 ---	
A	US,A,4 065 105 (LUSSIEZ) 27 December 1977 ---	
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A	US,A,4 874 248 (LUETZELSCHWAB) 17 October 1989 ---	
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Date of the actual completion of the international search	Date of mailing of the international search report
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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